Technology in the Lab Part II: Practical suggestions for using probeware in the science classroom
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Technology in the Lab

Part II: Practical suggestions for using probeware in the science classroom

Nüsret Hisim

Probeware is increasingly being implemented in science classrooms because it is less expensive than it used to be and improvements in hardware and software have made it more accessible to students and teachers. Many probes or sensors can now simply be connected to a computer, calculator, or other handheld device, and will immediately begin to collect data once connected.

Inquiry experiments allow students to apply what they know (or think they know) to topics of interest in a more unstructured manner. Using probeware for inquiry labs has a number of advantages. First of all, most students enjoy working with computers and already come to the laboratory with at least a basic knowledge about computers. Probeware allows students to quickly gather data and examine graphical and numerical representations of the results. Probeware also allows students to gather more accurate data and, in some cases, make measurements that could not be made with manual instruments. With probeware, students can investigate experiments that take place over extended time periods and that would be tedious to monitor by direct observation and manual instruments.

This article focuses on probeware activities I have used in the classroom and worked on with individual students as science fair projects. By being able to collect, analyze, and adjust data so quickly and easily with probeware, students can

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investigate science topics of interest to them in an exciting manner.

Testing batteries

Students today are surrounded by handheld devices, such as cell phones, music players, and games. Batteries are a big part of their lives. One way to study batteries is by having students conduct the following investigations:

- Which brand of battery is best? Are more expensive batteries really worth the cost?
- Are rechargeable batteries as good as one-use batteries?
- How much does the capacity of a rechargeable battery drop off after several uses?
- How do various types of batteries (e.g., nickel-cadmium, alkaline, nickel-metal hydride, lithium ion) compare?
- What role does temperature play in battery life?
- What batteries are best for light loads (e.g., music players, cell phone) and which are best for high-power use (e.g, toys with motors, drills)?

Students can investigate the questions above by using voltage probes available with most probeware systems to monitor the battery status of any electrical device during use. This is easiest if the device uses replaceable, individual batteries (AAA, AA, C, or D cells). To begin the investigation, the teacher or student should simply clip one lead of the voltage probe to the negative end of the first battery and the other lead to the positive lead of the last battery and read the battery-pack voltage. Note that the input impedance of any probeware system is relatively high, so the voltage probes will not draw any significant current that would affect the experimental results.

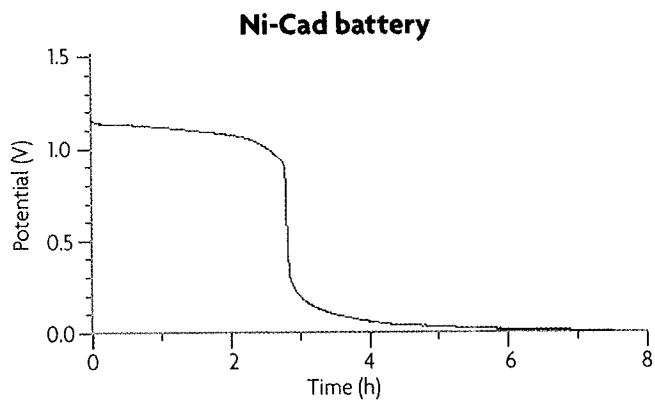
These investigations can take a long time; doing this experiment without some system for automatically plotting the voltage versus time can be boring for students. Most software can now be set to collect and plot data at nearly any interval of time and for as long as desired. Depending on the load, some of these batteries can last a long time. For example, a CD player may run for a number of hours on a fresh set of alkaline batteries. The software would need to be set up to record the voltage, for example, every 15 minutes for 10 hours. Part of the investigation could include determining the limits. Projects of this type might need to be set up and left undisturbed for a period of time. However, the computer or calculator does not have to be committed to the experiment for this long. Some interface devices can be set up to monitor and collect data remotely so that once the experiment is running, the computer, calculator, or handheld device can be disconnected.

Students may discover in inquiry investigations on battery discharge that different types of batteries have different shapes to their discharge curves (Figure 1). Students may also be surprised that the different battery types have different initial (fully charged) voltages.

FIGURE 1

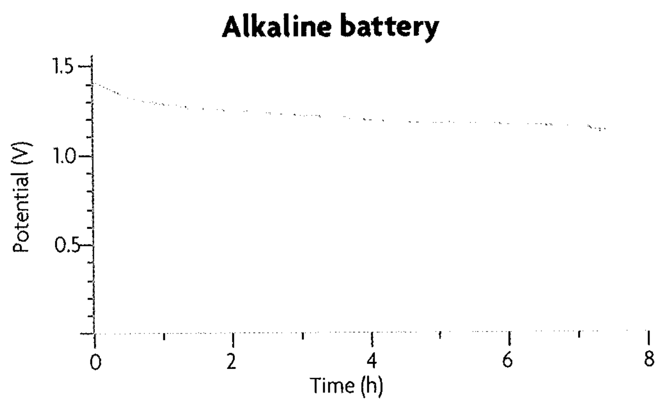
Sample discharge curves.

Ni-Cad battery discharge



GRAPHICS COURTESY OF DAVID VERNIER

Alkaline battery discharge



Friction studies

A standard physical science lab, which is often conducted as a "guided inquiry," involves investigating friction as an object is pulled along a horizontal surface. There are two ways to conduct this lab. One way is by pulling a rectangular block using string attached to a screw eye along a table and measuring the friction force. Rotating the block will vary the

surface area between the block and the table. The *normal* force (force pressing the two surfaces together) can be varied by adding weight to the block. The surfaces can be varied by changing the contact surface of either the block or the table. Adding sandpaper to one side of the block can provide an additional variable of interest.

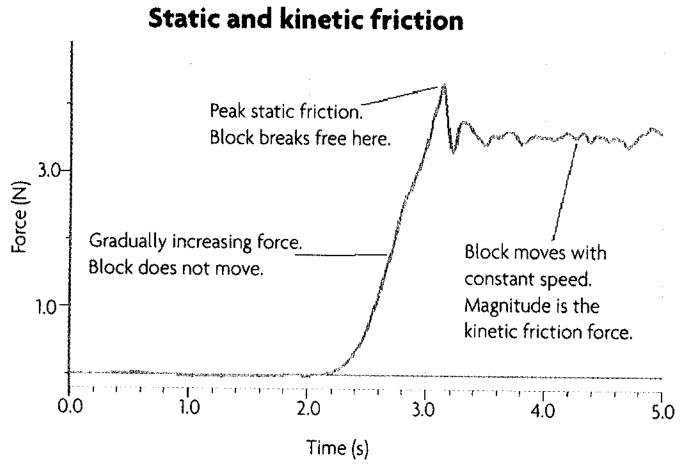
Another way of conducting the lab is by using shoes brought in by students. The variables are harder to control in this version of the lab, but students do enjoy bringing in shoes with different surface materials and treads. Testing various athletic shoes for different sports provides interesting inquiry activities, and can lead to discussions and investigations about the differing importance of friction in various sports.

No matter how the investigation is conducted, students can use probeware to monitor the frictional force needed to pull on the object, initially at rest, until it moves at a slow, steady rate. The probeware can create a graph of force versus time (Figure 2). Using probeware in this case is better than using the traditional spring scale. With a spring scale, the force reading bounces around considerably while the object is being pulled. The same variation in the force readings occurs with a probeware system, but students can examine the graph of force versus time and use the analysis features of the software to calculate the average force.

Most graphs made by students will resemble Figure 2. Hopefully students will notice that force increases and then decreases slightly in a typical experimental run. This offers a great introduction to the concepts of static and dynamic friction and can lead to discussions about automotive braking and driving on snow and ice.

FIGURE 2

Typical force versus time graph for an object pulled from rest.



Testing UV protection

Probeware can also be used to study the relationship between ultraviolet (UV) light and the materials designed to block it. Although this investigation can also be done with commercially available UV beads (see "To Tan or Not to Tan?" in the September 2005 issue of *The Science Teacher*), the possibilities for inquiry investigations increased dramatically once relatively inexpensive UV sensors became available for use with probeware systems. Students may find the following inquiry investigations interesting, particularly because the results have health implications:

> Can you get a tan or sunburn through a glass window?
> Which sunglasses really block UV? Are the expensive ones that much better?
> Are the Sunburn Protection Factor (SPF) numbers on sunscreen packaging really meaningful?
> Is there a limit to how protective SPF really is? In other words, is SPF 45 three times as effective in blocking UV light than SPF 15?
> How important is it that the sunscreen be applied in a thick layer?

These investigations can be conducted on a sunny day outside or at an open window. Students can measure the percentage reduction in UV intensity as they hold the various objects between the sun and the UV sensor. Unlike UV beads, the measurements can be made instantly, allowing more time for inquiry. Of course, students must not look directly at the sun when performing these experiments. Artificial UV sources may also be used, but students' eyes should be protected if such sources are brought into a classroom.

Another variation of these inquiry labs involves sunscreens. Most plastic-wrap materials used for storing food in the kitchen or refrigerator do not absorb much UV. Students can investigate this assertion with simple tests. Then, if students are curious about whether sunscreen really works as advertised, they can smear sunscreen on the plastic wrap and then hold the plastic wrap between the UV sensor and the sun to see the reduction in UV. Students can then take the investigation further by looking at whether a sunscreen of SPF 4 really cuts the UV to one-fourth the initial intensity. Some probeware is designed specifically for UVA and UVB radiation, so students can extend the

investigations to find differences in the way these two wavelength ranges are transmitted.

Investigating intermolecular forces

To compare the strength of van der Waals forces and hydrogen bonding, students can monitor the change in temperature as they evaporate small quantities of liquids from the tips of temperature probes. Students then compare the shapes of the curves to the molecular mass and structure of the compounds.

Before long, students will start inquiring about other compounds. I ask students to predict how the temperature curve will compare to the compounds they have already experimented with. This simple activity is made more meaningful and interesting by using probeware; it is extremely tedious when using a thermometer and manually graphing the data.

Inquiry competitions

One great way to involve students in inquiry-style investigations is by organizing contests that use probeware. The teacher presents a challenge, with specific rules and limitations, and students try to use their scientific knowledge and creative talents to come up with a winning entry. The key is for the teacher to carefully construct the ground rules to provide a challenging, interesting contest. (Safety note: Students must wear safety goggles and follow standard safety protocols during all of the contests.) Contest examples include:

Insulation contest: Students insulate a bottle of hot water to try to minimize the heat loss. They then compare rates of cooling using a temperature probe.

Air pressure contest: Students are challenged to come up with a way to produce the highest pressure possible in a clean, dry, plastic soft drink bottle that they will connect to a probeware pressure sensor. Rules must be established in advance. Students should be told that they can only use parts of their bodies to change the pressure in the bottle. For example, they can squeeze, rub, or even step on the bottle. The winner has to be able to show the teacher a graph with the highest sustained pressure (highest pressure graphed for 10 seconds).

Freezing point depression contest: Students are challenged to produce the lowest temperature possible using water, ice, and a salt. What salt is best? What concentration is best?

Bridge-building contest: This contest, using balsa wood, toothpicks, or other materials, has been around for years, but probeware improves it. The bridges are tested (to destruction) using a force sensor connected to a computer to graph force versus time. The highest peak force wins the contest. It is a great spectator sport.

Solution combination: Students are given two solutions that react exothermically when mixed. My students, for example, have conducted this experiment with equimolar solutions of $NaOCl$ and $Na_2S_2O_3$ (0.5 M solutions of each). Students are challenged to produce the largest temperature increase they can. They cannot increase the concentration of the solutions, but only adjust the ratio of the two. The winner is the student who combines the solutions in the correct stoichiometric ratio.

Packing contest: Students are challenged to pack an object with a probeware accelerometer in a specific-sized protective container. The objects are dropped from a specified height and the entry with the lowest peak acceleration wins. This is better than the traditional "egg drop contest," because it is quantitative and there is less to clean up.

My favorite inquiry lab

My favorite type of inquiry lab occurs when students choose their own topics to investigate. Throughout the school year, students are bound to ask interesting questions. They might question how something works or why something is done the way it is done, or which product is best to use. Many of these questions provide the seed for great inquiry labs, especially when a motivated student wants to learn more about the topic at hand. Sometimes the question will be interesting to enough of the class to spark a classwide investigation. If probeware is used throughout the year, students will be comfortable enough with it to suggest using it in their own investigations.

The beauty of the current state of educational science technology is that authentic technology is now used in the high school classroom. Using this technology in the classroom has never been easier or more cost-effective. Students can get involved in science in much the same way professional scientists do. Exciting new devices are being developed and adapted every day. The challenge is to continue bringing this technology to our students, because it offers a marvelous way to increase enthusiasm in our classrooms.

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